STAT

FOR OFFICIAL USE ONLY

CLASSIFICATION ~~RESTRICTED~~ C

~~SECURITY INFORMATION~~

CENTRAL INTELLIGENCE AGENCY

INFORMATION FROM

FOREIGN DOCUMENTS OR RADIO BROADCASTS

REPORT

CD NO.

STAT

COUNTRY	USSR	DATE OF INFORMATION	1952
SUBJECT	Scientific - Electronics, accelerometers		
HOW PUBLISHED	Monthly periodical	DATE DIST.	13 Nov 1953
WHERE PUBLISHED	Moscow	NO. OF PAGES	14
DATE PUBLISHED	Jun, Dec 1952		
LANGUAGE	Russian	SUPPLEMENT TO REPORT NO.	

STAT

THIS IS UNEVALUATED INFORMATION

SOURCE Elektrichestvo

USSR ELECTRONIC INDICATORS AND ACCELEROMETERS

/Comment: The following is the full text of two articles from two issues of the Soviet periodical Elektrichestvo by Docent L. A. Goncharskiy, Candidate of Technical Sciences. Appended to each article is a bibliography. Figures referred to are appended at the end of the report. Numbers in brackets refer to appended bibliographies./

I. ELECTRONIC INDICATORS OF SMALL DISPLACEMENTS

Elektrichestvo, No 6,
Jun 1952, pages 62-65

Electronic indicators of small displacements are used for the measurement and recording of various mechanical quantities, e.g., lengths, displacements, vibrations, accelerations, pressures, and other mechanical parameters both under laboratory conditions and in the testing of machines and engineering structures. /3, 5, 6, 7/ These indicators are vacuum instruments with movable electrodes which are displaced by the action of external stresses. Fine membranes or tubes are used to transmit the displacements within the instrument.

The first instruments of this type were a variation of the diode tube in which the relative displacement of a movable anode under the action of external stresses was used to transform the displacement of the particular object into a change of electric current. /1/ Further refinements of this principle led to the development of a series of thermionic indicators whose operation was based on the control of plate current by the displacement of a movable electrode. The diode indicator with plane-parallel electrodes is the simplest in design and operating principle. Indicators of this type have high current sensitivity and relatively low plate power dissipation.

STAT

FOR OFFICIAL USE ONLY

CLASSIFICATION ~~RESTRICTED~~ C

STATE		NAVY		NSRB		DISTRIBUTION		
ARMY		AIR		FBI				

FOR OFFICIAL USE ONLY

RESTRICTED

STAT

A further refinement in the method of electric field control with a movable electrode was obtained by increasing the complexity of the field through the use of a movable or fixed grid. This made it possible to construct indicators which had considerably higher voltage sensitivity than diode indicators.

Along with the method of electric field control of thermionic indicators, several other special methods have been used. These are based on the use of systems of electrodes which make it possible to obtain a more advantageous dependency of relative variation of electric field intensity at a heated cathode as a function of the displacement of a control electrode. One of these systems employs the relative displacement of a thin, directly heated cathode in a homogeneous field/8/, and a second system is based on the use of electrodes having a toothed form./9/

The diode indicator of small displacements/1/ which we proposed in 1935 as a sound pickup is the simplest thermionic indicator of such displacements. Its schematic diagram is shown in Figure 1. Both electrodes, the cathode 1 and the anode 2, are placed in a vacuum and are plane parallel. The anode 2, attached to the lever 3, passes through the elastic wall 4 of the case and can be moved in the direction shown by the arrow. The outer end of the lever is connected to the object to be controlled.

Given a constant anode voltage, a change in the distance between cathode and anode causes a variation of electric field intensity between these electrodes and a corresponding variation of anode current.

The dependency of the space-charge controlled anode current upon the distance between the parallel electrodes can be derived given the following limiting conditions/2/:

1. The distance between electrodes is assumed to be small in comparison with their transverse dimensions, which allows us to consider the electric field between electrodes to be homogeneous.

2. The initial velocity of the electrons leaving the cathode is assumed to be zero.

3. A good vacuum exists in the indicator.

4. The anode and cathode are equipotential.

For the dependency of anode current of a thermionic indicator upon its parameters, we can write:

$$I_a = A\,\frac{S U_a^{3/2}}{a^2} \qquad (1)$$

where S is the surface of the electrodes, a is the distance between them, U_a is the anode voltage, and $A = 2.34 \times 10^{-6}$. Equation 1 shows that the anode current between plane-parallel electrodes of the diode indicator is inversely proportional to the square of the distance between them.

We now represent a small change of anode current, the anode current being a function of anode voltage and distance between electrodes, as a total differential:

$$dI_a = \frac{\partial I_a}{\partial U_a}\,dU_a + \frac{\partial I_a}{\partial a}\,da. \qquad (2)$$

Here $\frac{\partial I_a}{\partial U_a}$ characterizes the differential conductivity of the indicator

$$\sigma_i = \left(\frac{\partial I_a}{\partial U_a}\right)_{a=const.} \qquad (3)$$

FOR OFFICIAL USE ONLY

STAT

Its reciprocal, which shows the ratio of increments of anode voltage to increments of anode current for a fixed distance between electrodes of the indicator is defined as its differential internal resistance:

$$R_i = \left(\frac{\partial U_a}{\partial I_a}\right)_{a = const.} \tag{4}$$

$\frac{\partial I_a}{\partial a}$ The partial derivative of anode current with respect to displacement describes the dependency of anode current on the distance between electrodes for a constant anode voltage. This term defines the differential sensitivity of the indicator with respect to current for small displacements. In some electronic indicators, the differential sensitivity may differ substantially from the current sensitivity for large displacements. For displacements which are small compared with the distance between electrodes, the nonlinearity of the characteristic can be disregarded and the current sensitivity can be considered a constant. Henceforth, we shall define only the differential sensitivity with respect to current which we shall call simply the current sensitivity, expressed by the relationship:

$$\psi = -\left(\frac{\partial I_a}{\partial a}\right)_{U_a = const.} \tag{5}$$

We now define the voltage sensitivity of the indicator as the ratio of a small increase in the voltage drop across it to the displacement of the anode causing it for a constant anode current:

$$\phi = \left(\frac{\partial U_a}{\partial a}\right)_{I_a = const.} \tag{6}$$

To find the relationship between the voltage and current sensitivities of the indicator, we use equation 2, in which we make the total anode current differential dI_a zero, i.e., the plate current constant

$$\left(\frac{\partial I_a}{\partial U_a}\right) dU_a + \left(\frac{\partial I_a}{\partial a}\right) da = 0,$$

and substitute for the partial derivatives their equivalents R_i and ψ; then we obtain

$$\left(\frac{\partial U_a}{\partial a}\right)_{I_a = const.} = -R_i\,\psi, \tag{7}$$

where the left term of the equality is the expression for voltage sensitivity. Consequently, we see that the voltage sensitivity of the indicator is equal to the product of the current sensitivity and the differential internal resistance:

$$\phi = -R_i\,\psi. \tag{8}$$

Now let us use these relationships to find the dependency of the parameters of a thermionic diode indicator on the dimensions of the electrodes and the operating conditions, assuming that the anode current satisfies equation 1.

By using the relation 5, we find the magnitude of current sensitivity is

$$\psi = \frac{2ASU_a^{3/2}}{a^3}. \tag{9}$$

STAT

On the basis of 3, the value of differential internal conductivity is

$$\sigma_i = \frac{3ASU_a^{1/2}}{2a^2}, \tag{10}$$

and, according to 4, the value of the differential internal resistance is

$$R_i = \frac{2a^2}{3ASU_a^{1/2}}. \tag{11}$$

From 8, we obtain for the voltage sensitivity

$$\phi = \frac{4U_a}{3a} \tag{12}$$

Since the intensity of a homogeneous electric field between plane parallel electrodes is

$$E = \frac{U_a}{a}$$

the expression for the voltage sensitivity may be written in the form

$$\phi = \frac{4}{3}E. \tag{13}$$

Thus, the voltage sensitivity of a diode thermionic indicator with plane-parallel electrodes is equal to four thirds the intensity of the homogenmeous electric field existing between these electrodes.

A simultaneous increase in the current and voltage sensitivities of a thermionic indicator is not advantageous because it leads to an increase in the internal power dissipated. It is much more effective to increase the current sensitivity at the expense of the voltage sensitivity and vice versa. The diode thermionic indicator is inherently suited for operation into a low-resistance load and therefore a relatively high current sensitivity is most important. The thermionic diode indicator with plane-parallel electrodes whose parameters were defined above is the simplest of the thermionic indicators in both electrode assembly and electric field configuration.

By reducing the gap between the plane-parallel electrodes, one can obtain substantial electric field intensities in the gap, which, in turn, permits one to obtain considerable anode current densities with small anode voltages. This feature of diode indicators with plane electrodes makes them the most current-sensitive of all thermionic indicators of small displacements. It is easy to show that other electrode systems which would increase the parametric sensitivity also lead to an increase of voltage drop and for equal power dissipated on the anode will have lower current sensitivity than the diode indicator with plane electrodes. Only the most sensitive thermionic indicator with comb-shaped electrodes will have the same current sensitivity as a well-built diode indicator for the same dissipated power.

The nonlinearity of the volt-ampere characteristic of the thermionic diode indicator suggests the use of a symmetrical double-anode indicator which is schematically shown together with a bridge circuit in Figure 2. In this indicator, one anode is brought closer to the cathode while the other anode is removed slightly.

As was shown by Gunn [3], and also by Grekhova and Vasil'yev, a sensitive micrometer can be made by connecting a technically sensitive portable microameter into the diagonal of the bridge. This instrument operates accurately and reliably without any amplification and each scale division represents 1/10,000 mm. Experience has shown that for displacements which do not exceed one tenth of the gap between electrodes, the double-anode micrometer connected in a bridge circuit gives good scale linearity. The scale nonlinearity does not exceed one percent of maximum deflection. The application of a double-anode indicator can also prove effective in conjunction with amplifiers, especailly in the small installations used for the study of dynamic processes.

Appendix

The signals generated by any parametric indicator of small displacements, including electronic indicators, ordinarily do not exhibit a single-valued dependency on the magnitude of the displacements measured. This is due to the fact that the intensity of the electrical signals obtained is determined, on the one hand, by a change of the basic parameter of the indicator and, on the other hand, by the intensity of the energy flow circulating in the indicator. The fact that the dependency of the signal upon displacement is not single-valued makes it expedient to use a universal method for the comparative evaluation of the sensitivity of the parametric indicator. This method is not complicated by requiring the consideration of the electrical operating conditions of the indicator. In this method, the relative variation of one of the basic parameters of the indicator is related to the displacement causing the variation. In the future, we shall call this criterion the parametric sensitivity of the indicator.

In line with the above, we will define the parametric sensitivity η as the quotient of the relative variation $\frac{dB}{B}$ of the basic parameter B divided by the relative displacement dl, i.e.,

$$\eta = \frac{\frac{dB}{B}}{dl} [cm^{-1}]$$

Let us now find the relationship between the parametric and the electrical sensitivities of a parametric indicator assuming that the basic parameter used to determine its parametric sensitivity is the internal resistance R. Then we may write the expression for the parametric sensitivity in the form:

$$\eta = \frac{\frac{dR}{R}}{dl}\ cm^{-1}.$$

Let us now relate the current sensitivity of the indicator with its parametric sensitivity (for a constant voltage on the indicator).

For this, we transform the last equation by substituting in it the value

$$R = \frac{v}{i}.$$

After this substitution, we obtain, using 8

$$\eta = \frac{\psi}{i},$$

or

$$\psi = -\eta i.$$

Consequently, the current sensitivity of a parametric indicator is equal to the product of its parametric sensitivity and the current flowing in it.

We now relate the voltage sensitivity with the parametric sensitivity by substituting in expression 11 the value found for the current sensitivity $\phi = \eta R_i i$; substituting also

$$i = \frac{v}{R},$$

we obtain finally

$$\phi = \eta \frac{R_i}{R} v.$$

Therefore, the voltage sensitivity of a parametric indicator with the nonlinear volt-ampere characteristics which are inherent in some electronic indicators is equal to the product of the voltage drop on the indicator and its parametric sensitivity and the ratio of the differential internal resistance to the total internal resistance of the indicator.

For indicators with linear volt-ampere characteristics, $R_i = R$, and the expression found for relating the voltage and parametric sensitivities takes on the form:

$$\phi = \eta v.$$

BIBLIOGRAPHY

1. L. A. Goncharskiy Certificate of Authorship 47827, 9 Dec 1935. Byulletin' izobreteniy, No 7, 1936.

2. G. A. Grinberg. Selected Problems in the Mathematical Theory of Electrical and Magnetic Phenomena. Izd-vo AN SSSR, 1948.

3. R. Gunn, Journ. of Applied Mechanics, VII, 2, 1941.

4. H. F. Olson, Journ. of Acoust. Soc. of Am., XIX, 2, 307, 1947.

5. R. C. Lewis, Journ. of Acoust. Soc. of Am., XXII, 3, 357, 1950.

6. Mechanical Displacement Input Electron Tube, Instruments, IX, VII, 420, 1946.

7. Mechano-Electronic Transducer RCA 5734. Rev. of Scient. Inst., XIX, 12, 926, 1948.

8. L. A. Goncharskiy. Certificate of Authorship 80630, 24 Dec 1948. Byulleten' izobreteniy, No 3, 1950.

9. L. A. Goncharskiy, Certificate of Authorship 78418, 17 Dec 1948. Byulletin' izobreteniy, No 1, 1950.

10. J. Rotstein. Electronics, XIX, 3, 230, 1946.

11. V. N. Mil'shteyn, "A General Method for Evaluating Small Changes in Electrical Circuits With the Help of Equivalent Circuits," Elektrichestvo, No 5, 1950.

II. ELECTRONIC ACCELEROMETERS

Elektrichestvo, No 12,
Dec 1952, pages 54-57

In a survey article [1], we gave a brief listing of the electronic indicators of mechanical quantities used as accelerometers. In this article, we turn our attention to the most widely used of these, i.e., electronic accelerometers with

STAT

moving anodes. The feasibility of producing diode electronic indicators with moving anodes was demonstrated by us in 1935.[2] Analysis of a diode system with a moving anode revealed that this system has high current sensitivity for small displacements of the moving electrode. This factor suggest the use of this instrument for direct recording of the observed processes with the help of an electromagnetic oscillograph.

We use the relationships found in the above analysis [15] [Article I, above] to clarify the dependency of the voltage and current sensitivity of a diode electronic indicator upon the parameters of the unit and its operating conditions.

Electronic accelerometers belong to the class of parametric indicators. The current of a parametric indicator is a function of the measured quantity θ and the voltage U applied to the indicator. Therefore, any small change of current dI in the indicator can be represented by the function

$$dI = \left(\frac{\partial I}{\partial \theta}\right) d\theta + \left(\frac{\partial I}{\partial U}\right) dU, \qquad (1)$$

where

$$i = \left(\frac{\partial I}{\partial \theta}\right)_{dU=0} \qquad (2)$$

is the current sensitivity of the indicator and

$$\sigma_i = \left(\frac{\partial I}{\partial \theta}\right)_{d\theta=0} \qquad (3)$$

is the internal conductivity of the indicator.

In this case, where the measured quantity is the acceleration w, equation 1 takes the form:

$$dI = \left(\frac{\partial I}{\partial w}\right) dw - \left(\frac{\partial I}{\partial U}\right) dU, \qquad (4)$$

where

$$i = \left(\frac{\partial I}{\partial w}\right)_{dU=0} \qquad (5)$$

is the current sensitivity of the accelerometer and the voltage sensitivity is

$$v = \left(\frac{\partial U}{\partial w}\right)_{dI=0} \qquad (6)$$

A displacement l of the moving electrode of the electronic accelerometer is directly proportional over wide limits to the component of acceleration measured parallel to the direction of displacement of the electrode

$$l = \frac{mw}{k} \qquad (7)$$

where k is the elasticity of the kinematic system of the mass m.

STAT

Substituting the value of v found in 7 into 5 and 6, we obtain

$$i = \frac{m}{k}\left(\frac{\partial I}{\partial l}\right)_{dU=0} \tag{8}$$

and

$$v = \frac{m}{k}\left(\frac{\partial U}{\partial l}\right)_{dI=0}, \tag{9}$$

where

$$\psi = \left(\frac{\partial I}{\partial l}\right)_{dU=0} \text{ and } \phi = \left(\frac{\partial U}{\partial l}\right)_{dI=0}$$

are the voltage and current sensitivities of the electronic indicator. [15] Consequently, the expressions 8 and 9 can be written in the form

$$i = \frac{m\psi}{k} \tag{10}$$

and

$$v = \frac{m\phi}{k} \tag{11}$$

Thus we see that the current and voltage sensitivities are directly proportional to the electrical sensitivity of the displacement indicator and to the absolute value of the mass, and inversely proportional to the elastic coefficient k.

Similar expressions can also be obtained for angular acceleration. Thus, it follows that the sensitivity of an electronic accelerometer is determined primarily by the linear and angular sensitivity of the electronic indicator of the displacement of the inert mass. By substituting the values of ψ and ϕ found in the work mentioned above [15] into 10 and 11, we obtain:

(a) For the current sensitivity of the indicator

$$i = \frac{2mASU_a^{3/2}}{ka^3}, \tag{12}$$

where $A = 2.34 \times 10^{-6}$; S is the active surface of the cathode; U_a is the anode voltage; and a is the distance between the anode and cathode.

(b) For the voltage sensitivity

$$v = \frac{4mU_a}{3ka} \tag{13}$$

or

$$v = \frac{4mE}{3k}, \tag{14}$$

where E is the electric field intensity between anode and cathode.

Let us now investigate systems with greater voltage sensitivity.

The first method suggesting itself for an increase of sensitivity on the basis of the known /15/ relationship

$$\phi = \psi R_i \qquad (15)$$

is that of increasing the internal resistance of the indicator, with a relatively small reduction in its current sensitivity. We found this solution as a result of using a collector, situated behind a mesh-type anode, so that the anode of the instrument did not have to function as a collector of anode current.

The schematic diagram of the diode indicator with a collector is shown in Figure 3. The operation of the collector reduces to the following. The electron current flowing from the cathode 1 of the indicator to its anode 2 passes for the most part through the mesh of the anode and is incident upon the collector 3 located behind the anode. In the diagram, the anode is shown made up of plates equipped with a rib. This design gives the anode maximum mechanical rigidity and at the same time permits the majority of the anode current to pass to the collector. Further, it is important to note that this design provides good shielding of the cathode from the collector, thus increasing the internal resistance of the instrument. Thus, if we assume that the resistance of the instrument is increased 100-fold and the current sensitivity is halved as a result of using the collector, the voltage sensitivity of the instrument will be increased 50-fold. If the sensitivity of the diode indicator without a collector is about $\phi_d = 500$ v/cm, then with the data given above, the sensitivity with a collector will be $\phi_c = 25{,}000$ v/cm.

Diode indicators with collectors used in bridge circuits may have two collectors with a single common anode. The schematic diagram of an indicator of this type is shown in Figure 4 together with its associated circuit. The indicator consists of a heated flat cathode 1 with a mesh-type anode 2 on both sides of it and also collectors 3 and 4 on both sides of the anode. The anode 2 is attached to a lever 5 which passes through the elastic wall of the indicator envelope. If the lever moves in the direction shown by the arrow one or the other side of the anode moves closer to the cathode, changing the ratio of electron currents to both collectors.

The second method of increasing the voltage sensitivity of the indicator consists of increasing the internal resistance while simultaneously increasing the electric field gradient at the surface of the anode by installing a fixed grid in the gap between the cathode and anode. The schematic diagram of an indicator with a movable anode and a fixed grid is shown in Figure 5. Let us consider its operation for the case of plane-parallel electrodes. As is known /3/, the anode current of a triode with plane-parallel electrodes can be represented by the equation

$$I_a = \frac{A S U_c^{3/2}}{a^2}, \qquad (16)$$

where A = 2.34 x 10^{-6}; S is the active surface of the cathode; a is the distance between cathode and grid; and U_c is the control voltage of the equivalent anode placed in the plane of the grid, equal to

$$U_c = \frac{U_g + D U_a}{1 + D} \qquad (17)$$

where U_a is the voltage on the anode of the triode; U_g is the grid voltage; and D is the permeability.

STAT

Let us express the rate of change w of the control voltage dU_c caused by a displacement dl of the movable anode in the form of a variation of the equivalent voltage dU_e on the fixed anode corresponding to it:

$$dU_c = \frac{D\,dU_e}{1+D} \tag{18}$$

Assigning a velocity λ to the change of equivalent anode voltage with respect to displacement

$$\lambda = \frac{dU_e}{dl} \tag{19}$$

we obtain from 18

$$dU_c = \frac{D\lambda\,dl}{1+D} \tag{20}$$

and therefore

$$w = \frac{dU_c}{dl} = \frac{D\lambda}{1+D} \tag{21}$$

Thus we see that the sensitivity of a mechanically controlled triode is directly proportional to λ and increases with an increase of permeability of the tube.

Let us find the expression for current sensitivity by substituting 16 and 21 into

$$\psi = \left(\frac{\partial I_a}{\partial l}\right)_{dU=0}$$

in the form

$$\psi = \frac{3ASD\lambda(DU_a+U_g)^{1/2}}{2a^2(1+D)^{3/2}} \tag{22}$$

Substituting the value of I from 16 into 22, we obtain

$$\psi = \frac{3D\lambda I_a}{2(DU_a+U_g)} \tag{23}$$

This shows that the current sensitivity of the instrument increases with an increase of λ and D.

Having defined the value of differential internal conductivity as

$$\sigma i = \frac{3ASD(DU_a+U_g)^{1/2}}{2(1+D)^{1/2}\,a^2} \tag{24}$$

and substituting 22 and 24 in

$$\phi = \frac{\psi}{\sigma i}, \tag{25}$$

we obtain

$$\phi = \lambda \tag{26}$$

For small displacements of the anode, the value of λ is close to the value of the electric field intensity E_a at the anode surface; this indicates that the voltage sensitivity of the triode with a moving anode is close to the value of E_a, i.e.,

$$\phi \approx E_a . \tag{27}$$

We now consider the operation of an indicator with a thin cathode, which we previously described.

The directly heated cathode 1 made from thin wire lies in a plane parallel to the two plane-parallel electrodes 2 and 3. The electrodes 2 and 3 are connected, as shown in Figure 6, to the terminals of the plate battery 4 and the cathode is connected to the midpoint of the battery. The instrument operates as follows: As long as the cathode of the indicator is in a region of electric field whose potential is below the potential of all sections of the cathode, the anode current of the indicator is zero. If the cathode is displaced in the direction of the anode, plate current will appear when the cathode reaches an equipotential surface at which the potential is equal to the potential of the negative part of the cathode. Further displacement of the cathode towards the anode results in a rapid increase of anode current.

Let us find the dependency of anode current in this instrument upon the geometry of the interelectrode space, using the following limiting conditions: (1) The diameter of the cathode is assumed to be negligibly small in comparison with the distance between electrodes and has no practical effect on the homogeneous field between electrodes; (2) the cathode is assumed to be equipotential; (3) the initial velocity of the electrons leaving the cathode is taken as zero; (4) a good vacuum is presumed to exist in the indicator; (5) the difference of potential between the cathode and the equipotential surface (the form of which is close to cylindrical and which we will consider the control voltage) surrounding it at a certain distance from the center of the cathode (equal to several filament radii) is assumed approximately directly proportional to the distance ε of the cathode from the equipotential surface whose potential is equal to cathode potential and to the intensity E of the homogeneous electric field.

According to the above, we have

$$I_a = B\,(\varepsilon E)^{3/2} , \tag{28}$$

where B is a coefficient determined by the geometrical dimensions of the electrodes. Substituting 28 into the expression for the current sensitivity of the indicator, we obtain after differentiation:

$$\psi_0 = \frac{3}{2} B E^{3/2} \varepsilon^{1/2} . \tag{29}$$

Using 28, we obtain the expression for the current sensitivity:

$$\psi_0 = \frac{3 I_a}{2\varepsilon} \tag{30}$$

from which B, which is difficult to determine, has been eleminated.

The differential internal conductivity of the indicator is

$$\sigma_i = \frac{B}{\varepsilon^{3/2}} \frac{\partial (U_a \varepsilon)^{3/2}}{\partial U_a} , \tag{31}$$

STAT

where ε, as well as $U_a = \xi E$ (ξ is the distance between electrodes 2 and 3), is a variable, because a change of anode voltage also causes a corresponding displacement of the equipotential surfaces.

Replacing in the last expression the distance ε of the cathode from the equipotential surface at which the potential is equal to cathode potential by its equivalent

$$\varepsilon = b - d, \tag{32}$$

where b is the distance of the cathode from electrode 3 and d is the distance of the equipotential surface at cathode potential from electrode 3 which, in turn, is equal to

$$d = \frac{U_c}{U_a} \xi \tag{33}$$

where U_c is the potential of electrode 3 with respect to the cathode, we obtain finally

$$\sigma i = \frac{B}{\xi^{3/2}} \frac{\partial (bU_a - \xi U_c)^{3/2}}{\partial U_a}, \tag{34}$$

and after differentiation

$$\sigma i = \frac{3bB(bU_a - \xi U_c)}{2\xi^{3/2}}. \tag{35}$$

Remembering that $\varepsilon U_a = bU_a - \xi U_c$ and using 29, we obtain

$$\phi_0 = \frac{U_a}{b} \tag{36}$$

If electrode 3 is connected directly to the cathode, the last expression reduces to

$$\phi_0 = \frac{U_a}{\varepsilon} \tag{37}$$

BIBLIOGRAPHY

1. L. A. Goncharskiy, "Electronic Accelerometers," Elektrichestvo, No 1, 1952, p 81.

2. L. A. Goncharskiy, "The A.S. 47827 Sound Pickup," Byulleten' izobreteniy, No 7, 1936.

3. G. A. Grinberg, Selected Problems in the Mathematical Theory of Electrical and Magnetic Phenomena, Izd-vo AN SSSR, 1948.

4. K. Gunn, "An Electronic Micrometer," Journal of Applied Mechanics, Vol VII, No 2, 1940, p. 49

5. M. T. Grekhova and R. P. Vasil'yev, "An Electronic Micrometer," Zavodskaya laboratoriya, Vol XII, No 9-10, 1946, p 882.

STAT

6. W. Ramberg, "An Electronic Accelerometer," Journal of Research, Nat. Bur. of Standards, Vol XXXVII, 1946, p 391.

7. W. Ramberg, "Measurement of Accelerations With the Help of the Electron Tube," AIEE Transactions, Vol LXVI, 1947, p 735.

8. "An Electronic Vibration Indicator," Catalog-Handbook of Laboratory Instruments and Equipment, No 25, p 68, Mashgiz, 1949.

9. "The Electron Tube as an Acceleration Indicator," Rev. of Scient. Instruments, Vol XVIII, No 1, 1947, p 67.

10. J. Rotstein, An Electronic Microphone," Electronics, Vol XIX, No 3, 1946, p 230

11. H. F. Olson, "An Electronic-Mechanical Transducer," Journal of Acoust. Soc. of Am., Vol XIX, No 2, 1947, p 307.

12. "The RCA-5734 Electronic-Mechanical Transducer," Rev. of Scien. Instruments, Vol XIX, No 12, 1948, p 926.

13. R. C. Lewis, "Design and Characteristics of a Highly Sensitive DC Accelerometer," Journal of Acoust. Soc. of Am., Vol XXII, No 3, 1950, p 357.

14. "The Improved Ramberg Electronic Indicator," Electronics, Vol XXIV, No 2, 1951, p 120.

15. L. A. Goncharskiy, "An Electronic Indicator of Small Displacements," Elektrichestvo, No 6, 1952, p 62.

16. "An Electron Tube for Measurement of Accelerations," Machinery Lloyd, No 14/A, 1949, p 75.

/Figures follow./

FIGURES

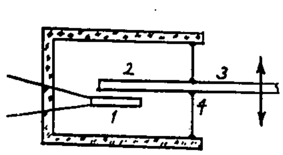

Figure 1.

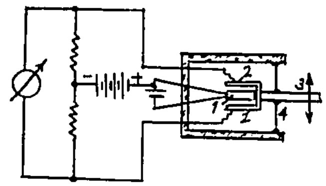

Figure 2.

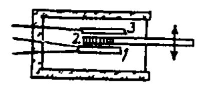

Figure 3.

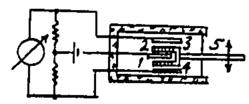

Figure 4.

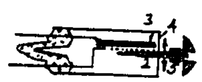

Figure 5.

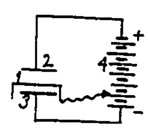

Figure 6.

- E N D -